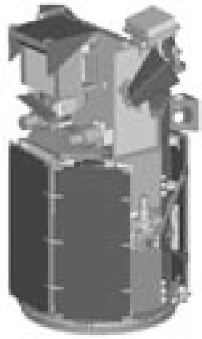
Glory



Glory URL
http://glory.gsfc.nasa.gov/

Summary

The Glory satellite consists of a spacecraft bus and three instruments and will be launched from the Vandenberg Air Force Base aboard a Taurus 2110 launch vehicle currently scheduled for 2007. Glory's remote sensing mission is designed to 1) collect data on the optical, microphysical, and chemical properties, and spatial and temporal distributions of aerosols and clouds; and 2) continue collection of total solar irradiance data for the long-term climate record.

Instruments

- Aerosol Polarimetry Sensor (APS)
- Cloud Camera (CC)
- Total Irradiance Monitor (TIM)

Points of Contact

- *Glory Project Scientist:* Michael Mishchenko, NASA Goddard Institute for Space Studies (GISS)
- *Glory Deputy Project Scientist:* Larry Travis, NASA GISS
- *Glory Project Manager:* Richard Burg, NASA Goddard Space Flight Center (GSFC)

Mission Type

Earth Observing System (EOS) Systematic Measurements

Launch

- *Date and Location:* 2008 from Vandenberg Air Force Base, California
- *Vehicle:* Taurus 2110

Key Glory Facts

Orbit:
Type: Sun-synchronous
Descending Node: 10:30 a.m.
Altitude: 824 km ± 30 km
Inclination: 98.7° ± 0.15°
Period: 101 minutes
Repeat Cycle: 16 days

Dimensions: 1.9 × 1.4 × 1.4 m

Mass: 482 kg at launch

Power: 320 W

Downlink: X-Band/S-Band

Design Life: 3 years with a 5-year goal

Glory Partners

Space Network: The Tracking Data and Relay Satellite System operated by NASA's Space Network.

Mission Operations Center (MOC): Based at the mission operations support contractor facility and is the sole facility for the operation of the spacecraft and the generation of the command uplink.

Ground Station: Commercial ground stations provide the space-to-ground RF communications with the Glory satellite. The primary ground station is located in Alaska and the backup is located in Norway.

APS Science Operations Center (SOC): NASA GISS

TIM SOC: Colorado University-Boulder's Laboratory for Atmospheric and Space Physics

Data Archive and Distribution: NASA GSFC Earth Science Distributed Active Archive Center (GES DAAC)

Ground Segment: Consists of the commercial ground stations, MOC, APS SOC, TIM SOC, GES DAAC, and various networks that connect them.

Relevant Science Focus Areas

(see Research Program section)

- Atmospheric Composition
- Carbon Cycle, Ecosystems and Biogeochemistry
- Climate Variability and Change
- Water and Energy Cycle

Related Applications

(see Applications Program section)

- Air Quality
- Carbon Management
- Ecological Forecasting
- Invasive Species
- Public Health

Glory Science Goals

- Perform aerosol and aerosol-cloud interaction research with data collected on the optical, microphysical, and chemical properties.
- Perform continued measurements of total solar irradiance for long-term climate studies.

Glory Mission Overview

Glory is a remote sensing spaceflight mission designed to 1) collect data on the optical, microphysical, and chemical properties, and spatial and temporal distributions of aerosols and clouds; and 2) continue collection of total solar irradiance data for the long-term climate record. The mission accomplishes these objectives by deploying two separate science instruments aboard a Low Earth Orbit (LEO) satellite, the Aerosol Polarimetry Sensor (APS) and the Total Irradiance Monitor (TIM).

APS will collect global aerosol and cloud data based on multi-angle along-track polarimetric and radiometric measurements taken within the solar reflective spectral region (0.4 to 2.4 µm). Measurements of spectral polarization and radiance are restricted to the sunlit portion of the orbit and, since clouds can have a significant impact on the quality of polarimetric retrievals, an onboard cloud camera is used to distinguish between clear and cloud-affected scenes. The three-year mission life (five-year goal) provides the minimum duration to observe seasonal and regional trends and characterize the evolution of aerosols during transient climate events (El Niño, volcanic eruptions, etc.)

TIM will collect high accuracy, high precision measurements of total solar irradiance (TSI) using an active cavity radiometer that monitors changes in incident sunlight to Earth's atmosphere. Because TIM is designed to operate nominally in a solar-viewing orientation, it is mounted on a gimbaled platform that accommodates targeting independent of the spacecraft's nadir viewing attitude. TIM is a heritage-design instrument that was originally flown on the SORCE satellite launched in January 2003.

The Glory satellite will be flown in a nominal 824 km, sun-synchronous orbit with a nominal descending node (north to south equatorial crossing) at 10:30 a.m. mean local time. This orbit was selected to coordinate observations made by the Visible Infrared Imaging Radiometer Suite (VIIRS) on the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) satellite with APS. From this altitude, the APS scanning sensor generates along-track, multi-angle photopolarimetric measurements with a ~6.6 km circular geometric instantaneous field of view. The sensor scans Earth over a nominal field of view

Glory Instruments

APS

Aerosol Polarimeter Sensor

APS is a multi-spectral polarimetric sensor that has the capability to collect visible, near-infrared, and short-wave infrared polarized radiometric data scattered from aerosols and clouds. APS is a continuous scanning sensor designed to make along-track, multi-angle observations of Earth and atmospheric scene spectral polarization and radiance.

Cloud Camera

The cloud camera is a dual-band, visible imager utilizing a non-scanning staring detector array that is analogous to a star tracker, but Earth-viewing. It consists of an optical imaging system that provides continuous cross-track coverage over a narrow swath centered on the APS along-track footprint.

TIM

Total Irradiance Monitor

TIM is an active cavity radiometer that records total solar irradiance. It has four completely identical radiometers to provide redundancy and to help detect changes in the instrument response caused by exposure to solar radiation. Each radiometer consists of a shutter, a 0.5-cm^2 precision aperture followed by a detector. TIM is mounted on a two axis, gimbaled platform that allows it to point the instrument independent of the spacecraft bus attitude.

of ±50° about nadir collecting a minimum of 120 angular samples per revolution with overlap of the individual swaths.

The Glory satellite will consist of a spacecraft bus and three instruments (APS, TIM, and cloud camera). It will be launched from the Western Test Range at Vandenberg Air Force Base (VAFB) aboard a Taurus 2110 launch vehicle. After the satellite has been placed into orbit, a 30 day in-orbit checkout begins. Verification of initial insertion parameters and early orbit ephemeredes will be made using the NASA Flight Dynamics Facility. Normal science operations immediately follow successful checkout. During that period, science data collection takes place on a near-continuous basis, interrupted only by special operations and anomalies. Mission operations and control are performed through the Mission Operations Center (MOC) located at the mission operations support contractor facility.

Ground station contacts are nominally required once per day permitting single-shift support and minimizing overall spacecraft operations. Mission planning, routine state of health monitoring, and spacecraft commanding is accomplished by the spacecraft contractor with instrument command files provided electronically by APS and TIM science operations centers (SOCs). The spacecraft is designed for automatic safing in the event of anomalies or critical failures.

A commercial ground station network is used for the Glory mission with the primary terminal located in Fairbanks, Alaska and backup located in northern Scandinavia, Norway. The ground station supports both low-rate S-Band command and telemetry link and high-rate X-Band return-only science downlink of 28 Mbps. A high-rate (2 Mbps) S-Band science data backup downlink is also supported. The primary ground station provides sufficient coverage for all nominal mission operations and science downlinks plus additional passes for on-orbit activation and checkout, anomaly resolution, or additional science downlink, as required. The Space Network's geosynchronous Tracking and Data Relay Satellite System (TDRSS) provides communications support to the Glory mission during early on-orbit operations and in contingency situations.

Science data are recorded at the ground system and routed to SOCs. Once received at SOCs, calibration of the science data is performed and science data processing algorithms are applied. Retrieval of VIIRS and OMPS data from the NOAA Comprehensive Large Array-data Stewardship System (CLASS) and science data from other sources is performed by SOCs, as required, to generate the necessary data products. After resulting data products are validated and assessed for accuracy by the science teams, final data products are archived and distributed to the user community by the NASA GSFC Earth Sciences Distributed Active Archive Center (GES DAAC).

Key APS Facts

Heritage: Pioneer–Venus OCPP, Research Scanning Polarimeter (RSP; airborne version of APS)

Instrument Type: Spectrophotopolarimeter

Scan Type: Along track

Incidence Viewing: ± 60° view zenith range at the surface of Earth

Calibration: Onboard polarimetric calibration and radiometric stability tracking

Field of Regard: ± 50° from nadir at satellite

Instrument IFOV: 8 mrad

Transmission Rate: N/A

Swath: 6.6 km cross track, 2200 km along track

Spatial Resolution: 6.6 km at nadir

Spectral Range: 0.4–2.2 μm

Measurement Type: Stokes parameters I, Q and U simultaneously in all spectral bands

Mass: 58 kg

Power: 45 W

Duty Cycle: 55%

Data Rate: < 160 kbps average

Physical Size: 51.7 × 58.6 × 48.2 cm

Direct Broadcast: No

APS

Aerosol Polarimeter Sensor

Aerosol Research

Aerosols play a crucial role in climate forcing and can contribute to both warming and cooling of Earth's atmosphere. Black carbon aerosols can contribute to global warming by absorbing the Sun's radiation and re-radiating the Sun's energy as infrared radiation that is trapped by Earth's atmosphere in much the same way that the windshield of an automobile contributes to a parked automobile heating up in the summer's Sun. Sulfate aerosols, produced from the sulfur dioxide gas that spews out of a volcano or from the burning of sulfur-bearing fossil fuels, reflects the Sun's radiation out into space and typically cause cooling. Aerosols, unlike greenhouse gases, have a short lifetime in the atmosphere. After they are produced they may interact with other atmospheric constituents including gases, particularly water vapor, other aerosols, and cloud particles, and are transported by the winds before being removed from the atmosphere by sedimentation or rainout over periods of order a week. Because of both natural and anthropogenic events, aerosols are constantly being replenished and the anthropogenic aerosols, since the beginning of the industrial age, have been increasing. Aerosol can also play a critical role in precipitation but again some species of aerosols may increase precipitation, while others may inhibit precipitation. While it is recognized that aerosols play a key role, because of the uncertainty of the composition of the aerosols in the atmosphere there remains great uncertainty in the effect that atmospheric aerosols have on climate—hotter or cooler, more rain or less.

In the framework of the Climate Change Research Initiative (CCRI), initiated in June 2001 to study areas of uncertainty about global climate change, research on atmospheric concentrations and effects of aerosols is specifically identified as a top priority. One of the activities CCRI calls out to support this research is improving observations for model development and applications from observing systems. To that end, the Glory mission will deploy an instrument that will help understand the climate-relevant chemical, microphysical, and optical properties, and spatial and temporal distributions of human-caused and naturally occurring aerosols. Specifically, Glory will be used to determine:

1) The global distribution of natural and anthropogenic aerosols (black carbons, sulfates, etc.) with accuracy and coverage sufficient for reliable quantification of:
   - the aerosol effect on climate
   - the anthropogenic component of the aerosol effect
   - the potential secular trends in the aerosol effect caused by natural and anthropogenic factors

2) The direct impact of aerosols on the radiation budget and its natural and anthropogenic components

3) The effect of aerosols on clouds (lifetime, microphysics, and precipitation) and its natural and anthropogenic components

Key Cloud Camera Facts

Heritage: Calipso Cloud Camera, Star tracker cameras.

Instrument Type: Spectroradiometer

Scan Type: Earth imaging

Incidence Viewing: Push broom imager

Calibration: Lunar views

Field of View: ± 9° cross track

Instrument IFOV: > 0.6 mrad

Transmission Rate: N/A

Swath: ±125 km cross track

Spatial Resolution: 500 m

Spectral Range: 412 and 865 nm bands

Mass: 3 kg

Power: < 10W

Duty Cycle: 50%

Data Rate: < 216 kbps maximum

Physical Size: TBD

Direct Broadcast: No

4) Investigate the feasibility of improved techniques for the measurement of black carbon and dust absorption to provide more accurate estimates of their contribution to the climate forcing function

In addition to the aerosol science objectives, Glory will be used to provide proof of concept and risk reduction for the NPOESS APS.

APS Data

APS threshold science requirements and science goals are characterized in following sections and described in terms of the specific data products. These data products, sometimes referred to as Environmental Data Records (EDRs), are:

For threshold science requirements—

1) Aerosol optical thickness
2) Aerosol particle size
3) Aerosol refractive index, single-scattering albedo, and shape
4) Cloud optical thickness
5) Cloud particle size distribution

For science goals—

1) Single scattering albedo derived from the ocean glint
2) Single-scattering albedo derived from the 412 nm aerosol differential absorption technique
3) Aerosol optical thickness derived from APS-VIIRS combined inversion
4) Fraction of fine mode aerosol derived from APS-VIIRS combined inversion

Aerosols are defined as suspensions of liquid droplets or solid particles in the atmosphere. Aerosols include, but are not limited to, smoke, dust, sand, volcanic ash, sea spray, polar stratospheric clouds, and smog. Although cloud particles can be considered as a particular type of aerosol, it is conventional to put them in a separate category. Specifically, liquid water clouds are defined as distinct optically thick particulate features composed of droplets with radii on the order of 10 µm in size. Cirrus clouds are defined as visible, or sub-visible particulate layers (either natural, or man-made, such as contrails), which reside in the upper troposphere/lower stratosphere and are composed of water ice crystals with sizes ranging from several micrometers to a millimeter.

Key TIM Facts

Heritage: SORCE

Instrument Type: Electrical substitution radiometer

Scan Type: Pointing

Incidence Viewing: Sun-viewing

Calibration: Deep space view

Field of View: 3.6° working cone

Instrument IFOV: N/A

Transmission Rate: N/A

Swath: N/A

Spatial Resolution: N/A

Spectral Range: Total (1 nm to 1000 microns)

Mass: 64 kg

Power: 75 W (average)

Duty Cycle: 100%

Data Rate: 539 bps

Physical Size: 17.7 × 27.9 × 27.2 cm

Direct Broadcast: No

Cloud Camera

Cloud Camera Research

The cloud camera is a high-spatial-resolution two-band radiometer intended to facilitate the identification of cloud-contaminated APS pixels and to determine the fraction of the pixel area occupied by clouds. Over ocean, the cloud camera will be used to determine aerosol load and fine mode fraction based on the aerosol microphysical model determined from APS measurements.

Cloud Camera Data

The analysis of cloud camera data to provide cross track coverage over a finite swath of aerosol load and fine mode fraction over the open ocean provides a back up to what is planned with APS and VIIRS in the event that VIIRS data is not available.

TIM

Total Irradiance Monitor

TIM Research

TSI, together with the absorption and reflection of this radiation by Earth's atmosphere, determines the global average temperature of Earth. The climate of Earth is directly affected by the balance between the intensity of the Sun and the response of the atmosphere. Changes in both the solar irradiance and in the composition of the atmosphere can cause global climate change. Solar irradiance is purely a natural phenomenon, while the composition of the atmosphere is strongly influenced by the byproducts of modern industrial societies. Over the past century, the average surface temperature of Earth has increased by about 0.5° C. Understanding whether the increase in temperature and the concomitant climate change are byproducts of natural events or whether the changes are caused by anthropogenic sources is of primary importance to the establishment of scientifically and economically effective policy.

The continued measurement of TSI to determine the Sun's direct and indirect effects on Earth's climate, at current state-of-the-art accuracy and without temporal gaps in the dataset, constitutes the solar irradiance requirement for the Glory mission. It is essential that there be no temporal gaps in the data, as any measured changes in the atmospheric temperature must be appropriately interpreted in the context of any changes in the solar irradiance.

TIM Data

The fundamental requirement for TIM is to make precise and accurate daily measurements of TSI and connect them to previous TSI measurements to form the long-term climate record. TSI measurement requirements are based on the requirement that the Glory TIM serve as continuity between the five-year SORCE TIM, in orbit since 2003, and the NPOESS TIM, scheduled to be in operation in the 2010 time frame. Technically, this mandates that the absolute accuracy (±100 ppm) and the relative accuracy (10 ppm) be maintained and that the Glory TIM provide calibrated overlap by more than six months with the heritage mission and the future mission.

Glory References

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Glory Data Products

Product Name or Grouping	Processing Level	Coverage	Spatial/Temporal Characteristics
APS			
Aerosol optical thickness at wavelengths in the 0.4–2.2 micron range	2	Restricted to 6.6-km swath along satellite ground track	6.6 km 9 IFOV at nadir viewed from multiple angles
Aerosol particle size distribution	2	Restricted to 6.6-km swath along satellite ground track	6.6 km IFOV at nadir viewed from multiple angles
Aerosol particle refractive index, single-scattering albedo, and shape	2	Restricted to 6.6-km swath along satellite ground track	6.6 km IFOV at nadir viewed from multiple angles
Liquid cloud optical thickness	2	Restricted to 6.6-km swath along satellite	6.6 km IFOV at nadir viewed from multiple angles
Liquid cloud particle size distribution	2	Restricted to 6.6-km swath along satellite ground track	6.6 km IFOV at nadir viewed from multiple angles
Single-scattering albedo derived from the ocean glint observations	2	As appropriate, dictated by observing opportunities	As appropriate, dictated by observing opportunities
Single-scattering albedo derived from the spectral contrast technique	2	Restricted to 6.6-km swath along satellite ground track	6.6 km IFOV at nadir viewed from multiple angles
Aerosol optical thickness derived from APS-VIIRS combined inversion *(see note below)*	2	Restricted to ±100-km swath along satellite ground track	6.6 km IFOV at nadir viewed by APS from multiple angles; cross-track radiance-only measurements by VIIRS
Fraction of fine mode aerosol derived from APS-VIIRS combined inversion *(see note below)*	2	Restricted to ±100-km swath along satellite ground track	6.6 km IFOV at nadir viewed by APS from multiple angles; cross-track radiance-only measurements by VIIRS
APS and Cloud Camera			
Aerosol optical thickness derived from APS-VIIRS combined inversion	2	Restricted to ±100-km swath along satellite ground track	6.6 km IFOV at nadir viewed by APS from multiple angles; cross-track radiance-only measurements by the Cloud Camera
Fraction of fine mode aerosol derived from APS-VIIRS combined inversion	2	Restricted to ±100-km swath along satellite ground track	6.6 km IFOV at nadir viewed by APS from multiple angles; cross-track radiance-only measurements by the Cloud Camera
TIM			
Precise and accurate measurements of total Solar irradiance	2, 3	N/A	Four measurments daily

Note: The Glory satellite will be flown in a nominal 824 km, sun-synchronous orbit with a nominal descending node (north to south equatorial crossing) at 10:30 a.m. mean local time. This orbit was selected to coordinate observations made by the Visible Infrared Imaging Radiometer Suite (VIIRS) on NPOESS Preparatory Project (NPP) satellite with APS.